

Investigating the Effect of the Activities Based on Explanation Assisted REACT Strategy on Learning Impulse, Momentum and Collisions Topics

Eser Ültay^{1*} Nedim Alev²
1. Assist. Prof. Dr., Giresun University, Faculty of Education, 28200 Giresun/TURKEY
2. Assoc. Prof. Dr., Karadeniz Technical University, Fatih Faculty of Education, 61335 Trabzon/TURKEY

Abstract

The purpose of this study was to investigate the effect of explanation assisted REACT strategy which was based on context-based learning approach on prospective science teachers' (PSTs) learning in impulse, momentum and collisions topics. The sequential explanatory strategy within mixed methods design was employed in this study. The first phase of the study in which quantitative data were collected represents the experimental aspect of the study, the second phase of the study in which qualitative data weregathered to support quantitative data represents the descriptive dimension. The study was carried out with 25 PSTs in the experimental and 25 in the control group. In this study, two-tier Impulse, Momentum and Collisions Concept Test (IMCCT) were used as a data collection tool. IMCCT which was consisted of 34 questions was administered as pretest before the intervention, posttest after the intervention and delayed test 9 weeks after the intervention. This study revealed that explanation assisted REACT strategy which was based on context-based learning approach was found more effective than the traditional teaching approach on impulse, momentum and collisions topic. Findings also showed that some of the alternative conceptions were significantly eliminated in the experimental group.

Keywords: alternative conceptions, explanation assisted REACT strategy, impuls, momentum and collisions, prospective science teachers, REACT strategy

1. Introduction

Context-based learning approach which foresees using familiar contexts in relating students' experiences to the new knowledge is built on the basis of the constructivist learning theory (Crawford 2001; Imel 2000). However, new knowledge begins to make sense when they are associated with events in people's environment and then appears useful to people (Souders 1999). In traditional teaching design, students are overloaded with a tremendous amount of subject matter knowledge and they often do not see the relations between topics (Pilot & Bulte 2006). Additionally, traditional teaching is insufficient in solving current problems of subject teaching and learning such as usefulness of the topic being taught in daily life and excess of topics without relating them with each other (Gilbert 2006). Because of this, knowledge should be placed in a need-to-know basis according to context-based learning approach. Thus, students could relate the topics with each other and see the usefulness of the new learnings in daily life, increasing students' interest and motivation.

Context-based learning approach does not only make students more active in learning, but also contributes to a more meaningful and permament learning within the relationship between physics and their daily life (Ng & Nguyen 2006). In addition, context-based learning approach helps students to better understand the natural environment to the world in which they live and (Lye, Fry & Hart 2001). Physics curriculum in some countries are rearranged according to context-based learning approach due to delivering positive results revealed from some context-based physics studies and being popular by the day in physics education (Wilkinson 1999). Context-based projects first began in Australia and New Zealand with VCE (Victorian Certificate of Education) in the field of physics. The other projects are SHAP (Salters Honers Advanced Physics) and SLIPP (Supported Learning in Physics Project) in United Kingdom, PiKo (PhysikimKontext) in Germany, ROSE (The Relevance of Science Education) in Finland, STEMS (Science, Technology Environment in Modern Society) in Israel, PLON (Dutch Physics Curriculum Development Project and NiNa) in the Netherlands (Wilkinson 1999).

The common feature of these projects is to present the desired content to the students by using the relevant context (Akpınar 2012). Through these projects, to eliminate students' common problem which is the inability to apply the scientific information to the personal and social life (Sanger & Greenbow 1996), to increase the intelligibility of scientific information (Taber 2007), to prevent boring science classes and to ensure students scientifically literate individuals (Akpınar 2012) wereintended. However, some studies revealed that teachers' knowledge and skills in applying context-based learning approach in real classroom settings were insufficient (Ayvacı, Ültay & Mert 2013).

In order to achieve context-based learning approach's aims, one of the strategies used in learning environments is the REACT strategy. CORD (Center for Occupational Research and Development) (1999a, 1999b), Crawford (2001) and Souders (1999) described the REACT strategy and its principles as shown in Table 1.



Table 1. The Principles of the REACT Strategy (CORD 1999a, 1999b)

Relating	Contextualization knowledge by establishing relationships with prior knowledge and past
Relating	experience
Experiencing	Learning by experiencing, discovering and inventing
Annlying	Data applications in learning environments such as classes and laboratories, and learning by
Applying	introducing concepts that will be used
Cooperating	Learning by sharing and communicating knowledgewith the others
Tuonafomina	Using the gained knowledge in a new context, unusual situations or environments outside the
Transferring	classroom

According to the REACT strategy, a selected topic which is related to daily life context(s) is taught in accordance with the principles of the relating, experiencing, applying, cooperating and transferring. There have been several studies in the literature indicating the problems encountered during the implementation of the REACT strategy and the need to improve the strategy (Coştu 2009; N. Ültay 2012; Ültay, Durukan & Ültay 2014).

In the REACT strategy, discussion and explanation parts were missing. Because teachersgot used to make explanations after each teaching activities and students got used to listen their teachers' explanations which were made for summarizing the activity; lacking of explanation part were obvious (Costu 2009; N. Ültay 2012). Also, discussion part was needed in the implementation of the REACT strategy (Costu 2009). Class discussions may have guided students to think the subject from different viewpoints. Thus, discussion may also be added to the REACT strategy (Coştu 2009). To conclude, several experimental research findings indicated that the REACT strategy needs to be refined (Coştu 2009; N. Ültay 2012; Ültay et al. 2014). Coştu (2009), forinstance, suggested that explanation and discussion principles should have been added to the REACT strategy to prevent the failing points, and this requires further research to test the refined strategy. Additionally, Ültay et al. (2014) suggested adding explaining principle as a separate principle or adding to all present principles. Making explanation helps students to change unfruitful pre-existing ideas with the new ones because students often have difficulty in finding new thinking ways without the teachers' guiding (Özmen 2002). Therefore, teachers may help students make learning more meaningful by guiding, bringing students' experience together, explaining the results and creating new concepts (Akdeniz & Akbulut 2010). In this sense, explanation assisted REACT strategy which is the extended version of the REACT strategy by adding the explanation principle should be investigated that is the aim of this study. Apart from the REACT strategy, new strategies or teaching models should be developed for the implementation of context-based learning approach which is found as effective in learning environments in terms of increasing students' interest and motivation, relating content knowledge to daily life experiences, providing more meaningful learning.

On the other hand, when the context-based physics studies are taken into account, it is seen that force and motion (Akpınar 2012; Choi & Song 1996; Lye, Fry & Hart 2001; Park & Lee 2004; Rennie & Parker 1996, 1998), energy (Rennie & Parker 1998), electricity and magnetism (Finkelstein 2005; Pesman & Özdemir 2012), optics (Basir, Alinaghizadeh & Mohammedpour 2008; Testa, Lombardi, Monroy & Sassi 2011) and buoyancy force (Enghag, Gustafsson & Jonsson 2009) topics are highly studied. However, impulse, momentum and collisions are slightly preferred. Actually, impulse, momentum and collisions topic is an issue that students are familiar with their daily lives. For example, taw, collision of vehicles in traffic accidents, billiards game, recoiling after firing the weapon and fireworks show are among the events that students often face in their daily lives. Students firstly faced impulse, momentum and collisions at third grade in high schools but they studied force and motion topic which was the basis of the impulse, momentum and collisions topic from the third grade of primary school to the fourth grade of high school. Nevertheless, it is seen that students have many alternative conceptions about impulse, momentum and collisions topicas revealed in the current research results (Çirkinoğlu 2004; Kobayashi & Okiharu 2009; Şekercioğlu (Çirkinoğlu) & Kocakülah 2008; Tanel & Tanel 2010; Taşar, Ünlü & Kandil İngeç 2006; Ünlü, Kandil İngeç & Taşar 2006; Ünlüsoy 2006). Indeed, with the increasing importance given to the concept teaching in recent years, it is seen that most of the studies is seemed to be focused on the conceptual teaching of momentum and collisions (Fang 2012; George, Broadstock & Vásquez Abad 2000; Tanel & Tanel 2010). For instance, George et al. (2000) aimed to search the usage of technology and concept learning about collisions and conservation principles with the undergraduate students of physics department, while Tanel and Tanel (2010), Şekercioğlu (Çirkinoğlu) and Kocakülah (2008) and Ünlüsoy (2006) focused on determining the learning difficulties and misconceptions about energy and momentum. However, Fang (2012), George et al. (2000) and Kobayashi and Okiharu (2009) tried to eliminate students' alternative conceptions, in some studies eliminating alternative conceptions were not possible (Cirkinoğlu 2004; Kobayashi & Okiharu 2009).

Additionally, it is seen that various teaching methods and techniques were used in impulse, momentum and collisions studies. For example Ünlü et al. (2006) used concept maps in their study to investigate how the prospective teachers understood momentum and impulse concepts and how they relate these concepts in their



minds. Similarly, Kandil İngeç (2008) used concept maps as an evaluation tool. Ünlüsoy (2006) aimed to investigate the effect of cooperative learning on eliminating the alternative conceptions about impulse and momentum at the second grade in high school. In a similar vein, Sariay and Kavcar (2009) studied to determine the effect of cooperative learning on students' success. As seen, there a lot of studies about impulse, momentum and collisions, but in some studies like Çirkinoğlu (2004) and Tanel and Tanel (2010) were found unsuccessful at conceptual change. Furthermore, the studies revealed that students have still problems in relating these concepts (Kandil İngeç 2008; Taşar et al. 2006; Ünlü et al. 2006). Indeed, although an experimental design which revealed a successful result in conceptual change and conceptual learning, alternative conceptions in students' minds may still be existed because it is known that conceptual change takes a long time. Concepts in students' minds interact all the time with each other and even if an alternative conception is seemed as eliminated, after some time they can come back as a result of existing the other alternative conceptions (Çalık 2006).

To conclude, it is thought that it can be effective to teach the topic via relevant contexts at eliminating the alternative conceptions and establishing the relations between the concepts (Ültay & Ültay 2014). There are also few studies that used prospective teachers as participants in context-based physics studies. It is important to carry out the study with prospective teachers because when they learned in a right way, they conduct their scientifically accurate learnings to the future generations because prospective teachers tend to teach how they were taught. Teachers are the main actors shaping students' personality and their attitudes, and directly affecting their individual lives (Yapici 2007). Hence, the purpose of this study was to investigate the effect of explanation assisted REACT strategy which was based on context-based learning approach on PSTs' achievement on learning impulse, momentum and collisions topics.

2. Methodology

2.1 Reseach Design

The sequential explanatory strategy within mixed methods which includes two-phase design was employed in this study. The first phase of the study consisted of experimental research followed by the second phase of the study in which qualitative data were gathered to support quantitative data as stressed by Creswell (2013). In the first phase of this study, the objective was to determine the effect of teaching through the employment of explanation assisted REACT strategy on students' achievement in physics, which was examined through experimental design. In the second phase, on the other hand, qualitative data were gathered via interviews to explain, interpret and support the findings from the experimental phase.

2.2 Reseach Group

The research group was consisted of freshmen students studying at Science Education in the Faculty of Education of Giresun University. The study was carried out with 25 PST in the experimental and 25 in the control group. The prospective science teachers in the experimental group in which explanation assisted REACT strategy was used were coded as E1, E2, E3, ..., E25, and the prospective science teachers in the control group in which the traditional teaching approach was used were coded as C1, C2, C3, ..., C25. Six prospective science teachers were selected for the interview; three of them were females (E1, E13, E16) and three of them were males (E2, E14, E21) in the experimental group, and six were selected in the control group, four females (C1, C3, C9, C16) and two males (C2, C6). According to the IMCCT scores of prospective science teachers, three of them were selected from the group who had the highest score and three of them were selected from the group who had the lowest score. It is believed that these extreme positive and negative cases could provide in-depth information about the intervention.

2.3 Data Collection Tools

In this study, two-tier IMCCT was used as a data collection tool. The use of two-tier testing in educational settings began with Treagust (1988). Students make a choice among options that are predetermined in the first phase of the question; the second phase of the question which is open-ended gives more information about to what degree students know the concept (Çalık 2006). In addition, it is important to diagnosethe alternative conceptions that the students have about a topic (Tan, Taber, Goh & Chia 2005). The IMCCT which was consisted of 34 questions was administered as pre test before the intervention, post test after the intervention and delayed test 9 weeks after the intervention. The first tier of the questions was multiple choices, and the second tier of the questions was open-ended which gave opportunity to students for free writing about the reason of the choice made in the first tier. Some example questions from IMCCT were presented below:

a) A ball of 500 g with 2m/s velocity.



7. An object which has a perpendicular speed vector to the glass's surface hits the glass. Which object of the following is likely to break the glass more?

b) A ball of 300 g with 4m/s velocity.

c) A ball of 100 g with 9m/s velocity.e) A ball of 600 g with 3m/s velocity.	d) A ball of 50 g with 20m/s velocity.
Because,	
21. Two people on the top of two skateboards sta frictionless floor. One of them pushes the other ratione of them is heavier;	
a) The magnitudes of their momentums are equalc) The heavier one's momentum is smaller.e) Their momentums are equal.	al. b) The heavier one's momentum is bigger.d) They go equal paths in equal time.
Because,	

For the IMCCT's each question, the maximum score that can be taken is four points that are one point from multiple-choice section for correct choice, three points from open-ended section for scientifically accurate explanation. Considering that IMCCT includes 34 questions totally, the maximum score that can be taken from IMCCT is 34*4=136 points.

In this study, interviews were also used for data collection. As in IMCCT, the questions in the interview focused on diagnosing the participants' alternative conceptions about the topic, in order to explain, interpret and support the findings obtained from IMCCT. The interview protocol consisting of 15 questions was conducted with 12 prospective science teachers from the experimental and control groups, focusing on the alternative conceptions determined via IMCCT. Some example questions from the interview protocol follows "A vehicle with a mass of m is turning a corner without a speed change. Is impulse applied to this vehicle? *Explain with the reasons*.", "If two vehicles collide, how do you identify the type of the collision? *Explain with the reasons*."

2.4 Intervention

Two separate lesson plans were prepared according to the topic's objectives and explanation assisted REACT strategy's all principles were used in a cyclic process in the experimental group. All lesson materials which were used during the teaching period were developed by the first researcher and a physics education expert. "Impulse, Momentum and Collisions-1 (IMC-1)" booklet for the first lesson plan and "Impulse, Momentum and Collisions-2 (IMC-2)" booklet for the second lesson plan were developed. In both booklets, lesson content and questions were created by the help of some studies (Ayvacı et al. 2011a, 2011b; Bueche & Jerde 2003; Serway & Beichner 2002), the rest was developed by the researchers with the experts opinions.

Courses that were based on traditional teaching approach were carried out in front of the blackboard by using lesson plans and laboratory activity sheets. In necessary cases, everyday examples were given, class discussions were created and PSTs' ideas and thoughts were evaluated. The experiment which was done with Predict-Observe-Explain (POE) technique in the experimental group was done as a demonstration experiment in the control group. In the control group, lesson contents and questions were created by the help of some studies (Ayvacı et al. 2011a, 2011b; Bueche & Jerde 2003; Serway & Beichner 2002). Lessons were taught with presentation by the first researcher. The lesson objectives were determined by Higher Education Council in Turkey and they were the same with the experimental group. Similarly as in the experimental group, two separate lesson plans were created by considering expert opinions.

The first lesson plan which was implemented in the experimental and control groups was presented in Table 2.



Table 2. The First Lesson Plan of the Experimental and Control Groups

Group	Principle	e 2. The First Lesson Plan of the Experimental at The Role of the Researcher	The Role of the PSTs
Group	Relating -	Researcher wants PSTs to read "Ice Rink"	PSTs read "Ice Rink" text and try to
	Explaining -	text and find the cases related to impulse. In	find the cases related to impulse.
	Cooperating	the meantime, there will be no guiding.	After that they try to find the cases
		While PSTs are trying to find the cases and	and the reasons about impulse on the
		the reasons about impulse on the visuals,	visuals. They write on the blanks on
		researcher asks questions where needed and	the sheet.
		creates a discussion environment. He can	PSTs try to interpret the graphs they
		guide PSTs. He can make explanations about	draw about the impulse and
		unclear points about the topic.	momentum in groups. Then they
		He carefully listens to the PSTs'	make presentations and they share
		presentations and guides them about missing	their results.
		parts.	
	Experiencing	During the experiment, researcher goes to the	PSTs perform the experiment which
	- Explaining -	tables and ask questions PSTs where they	is based on POE technique.
d	Applying	have difficulty, he provide them to	The questions on the laboratory
no	11 5 6	interpretabout some cases and he makes	activity sheet are answered by
- 5		explanations and guide them to the right way	voluntary PSTs and the responses are
tal		when needed.	discussed. In the meanwhile, "Ice
nen		Researcher gives a research homework that	Rink" context is related to the
i.i.		should be done individually and warn them to	experiment.
Experimental Group		present the homework in the following	
Ä		course.	
	Applying -	While PSTs solve the questions on the	PSTs individually solve the
	Explaining	blackboard, researcher asks them about some	questions in the test about impulse
	2	missing points for better understanding. He	and momentum. Then voluntary
		helps them to think more deeply. In addition,	PSTs can solve them on the
		he makes necessary explanations when PSTs	blackboard.
		had difficulty.	olucito dal di
	Transferring -	Researcher guided PSTs to the right way	The homework which was given in
	Cooperating -	during their presentations if they have	the previous lesson by the researcher
	Explaining	missing or false points.	is presented by the voluntary PSTs.
	Enpluming	In addition, researcher helps to make the	PSTs answer and present the
		topic's transferring to the rocket motions.	responses of the group work entitled
		Then, researcher presents the motion of	with "Daily life examples of
		rocket for better understanding and solves	momentum conservation and their
		examples.	explanations".
	Attention and	Researcher begins the course with asking	PSTs try to answer the researcher's
	motivation	what impulse and momentum can be. Then	questions and they discuss them in
	monvanon	he asks if momentum is conserved or not in	the class.
		some examples and explain the reasons. He	the class.
		helps PSTs' examples relating to daily life. In	
		doing so, he attracts PSTs' attention to the	
₫	Transition to	Passarahar presents impulse mamantum	PSTs listen to researcher's
lou		Researcher presents impulse, momentum,	
5	course	momentum conservation and rockets topic. In	presentation and try to respond the
rol		the meantime, he asks questions by question-	questions he asked. PSTs ask for the
Control Group		answer technique and tries to keep PSTs'	lacking points and try to understand
Ŭ	Individual	attention alive.	better.
	Individual	Researcher performs the experiment entitled	After PSTs watch the experiment,
	learning	with "The changes of momentum in an	they try to answer the questions and
	activities	impulse" by demonstration technique.	fill in the blanks on the laboratory
	F1	December of months 1 (d. 1.1	activity sheet.
	Evaluation	Researcher asks questions about the whole	PSTs try to respond the questions
1		topic and he wants PSTs to relate the topic with daily life.	researcher asked and relate the topic to daily life.



2.5 Data Analysis

Scoring criteria used in this study to analyze IMCCT was created by utilizing the scoring scales mentioned by Marek (1986). The categories used in IMCCT and the criterias of these categories are given in the following:

- Sound Understanding (SU 3 points): This category includes PSTs' scientifically completely accurate descriptions.
- Partial Understanding (PU 2 points): This category includes PSTs' explanations which show some part of the correct answer but do not contain wrong information or alternative conception.
- Partial Understanding with Specific Alternative Conception (PUSAC 1 point): This category includes partial understanding of scientific explanation with some alternative conceptions.
- Specific Alternative Conception (SAC-no point): This category includes PSTs' false explanations which are inconsistent with the scientifically correct answer and these answers can contain some alternative conceptions.
- Irrelevant/Empty/Unclear (IEU no point): This category includes PSTs' irrelevant or not understood answers. PSTs can leave the question empty.
- **Right Option (RO − 1 point):** This category includes PSTs' selecting right option of the first phase of the question.
- False/Multiple Option (FMO no point): This category includes PSTs' selecting false/multiple option of the first phase of the question.
- Empty (E no point): This category includes PSTs' not selecting an option.

The responses of PSTs were evaluated and scored as in explained above and then their total scores of pre, post and delayed tests were statistically analyzed with SPSS 16.0 software. Because measurement is used in data analysis of IMCCT instead of ranking, counting and marking, the sample is chosen randomly, the sample consists of 50 participants (bigger than 30), p=0,086 (p>0,05) is found for Kolmogorov-Smirnov test, p=0,102 (p>0,05) is found for homogeneity of variances and normal distribution is seen at 0,05 level; parametric tests are preferred in data analysis of IMCCT.

In this study, recorded interviews were transcribed verbatim and analyzed deductively, using the categories in the analysis of IMCCT such as "Sound Understanding (SU)", "Partial Understanding (PU)", "Partial Understanding with Specific Alternative Conception (PUSAC)", "Specific Alternative Conception (SAC)" and "Irrelevant/Empty/Unclear (IEU)".

2.6 Validity and Reliability

In order to increase the validity and reliability all teaching materials and data gathering tools were piloted after taking expert opinion. In pilot studies, IMCCT was administered 55 PSTs and interviews were conducted with 12 PSTs. Thus, the responses of PSTs were examined and necessary additions and subtractions were done and the questions were rearranged. All lesson plans, teaching materials and data collection tools were examined by four physics education experts to provide face and content validity. They were also checked by language experts and necessary arrangements were done for clarity. In addition, in accordance with the opinions of experts IMC-1, IMC-2, IMCCT and interviews were rearranged in terms of layout and readability.

In data analysis of IMCCT, a scoring scale was used which was developed in analyzing the data of pilot study by the first researcher. However, this thinking would have not made very objective and accurate results, to ensure the reliability a different physics education expert was asked to evaluate the IMCCT data and then the match comparison between the two valuerwas calculated by SPSS 16.0 software package, and Cohen's Kappa (Cohen's kappa factor) value was found as 0,92 which was accepted as perfect match by Landis and Koch (1977)'s classification. After this stage, researchers evaluated the IMCCT data.

Because the questions in IMCCT were two-tier, item analysis was not performed (Çalık 2006; Ng & Nguyen 2006; Rennie & Parker 1998; Wilkinson 1999). But the reliability coefficient (cronbach alpha) was calculated as 0,87. If the reliability coefficient was higher than 0,70, the test can have been accepted as reliable (Hair, Black, Babin, Anderson & Tatham 2006).

Before the intervention and data collection process, the first researcher informed PSTs about that "this intervention and data were not used for assessment purpose", "the intervention and data will have been used only for this research" and "except some demographic information, everything will have not been shared with the readers". In addition, the intervention and data collection process were conducted in an environment where PSTs were familiar, namely in the classroom where PSTs were being taught.

In the second tier of the questions of IMCCT and interviews, data reduction were made, critical responses were identified and code lists were created at three different times to increase the study's credibility and consistency. These codes were classified into themes/categories. Additionally, after the interviews, data were checked by the PSTs who were interviewed for the puspuse of respondent validity. The results obtained were supported by providing enough raw data for the reader as Miles and Huberman (1994) stressed that providing



enough raw data is the information required for confirmability.

For the ethical purpose, in the study PSTs' consents were taken about sharing data obtained from them. In addition, the participating PSTs were informed that no harm would come to them because of the nature and results of the study and some demographic information will have been shared (Drew, Hardman & Hart 1996). In the intervention and data collection process, some special dialogue passed between researchers and PSTs was not reflected in the data collection process to ensure the privacy and confidentiality principles. Furthermore, anonymity was provided by coding the PSTs in the experimental group as E1, E2, E3, ..., E25 and in the control group C1, C2, C3, ..., C25.

3. Findings

According to the groups, means and standard deviations of pre, post and delayed tests of IMCCT and the percentage changes between pre and post tests, post and delayed tests, and pre and delayed tests are shown in Table 3.

Table 3. Statistical Data of IMCCT

Groups	N -	Pre test		Post test		Delayed test		Percentage change (Δ %)		
		Mean	s.d.	Mean	s.d.	Mean	s.d.	Pre-Post	Post-Delayed	Pre-Delayed
Experimental	25	18,3	8,8	47,2	15,5	39,6	18,1	21,2	-5,6	15,7
Control	25	14,9	6,0	33,9	13,4	28,5	11,3	13,9	-4,0	10,0

According to Table 3, the means of pre tests of both groups are quite close to each other. When the post test scores of both groups are considered, it is seen that both groups' means are increased. The experimental group's mean increased to 47,2 and the control group's to 33,9. However, both groups' scores are decreased in delayed test. The experimental group's mean decreased to 39,6 and the control group's to 28,5 but they are still higher than the groups' pre test scores. The percentage change and mean scores as shown in Table 3 revealed that students in experimental group scored better than those in the control group. Independent samples t-test is performed to determine if a significant difference is present among pre, post and delayed tests of both groups and the results are shown in Table 4.

Table 4. The Results of Independent Samples T-Test for Pre Tests

C	NI	M	G-	0.1	4	
Group	N	Mean	SS	50	τ	p
Experimental	25	18,3	8,8	48	1 505	0.117
Control	25	14,9	6,0	48	1,393	0,117

There is no significant difference between pre tests of the experimental and control groups which is administered to compare the groups' conceptual understanding levels ($t_{(48)}$ =1,595: p>0.05). However, both groups' pre test means are close to each other, the experimental group's score is a little bit higher than the control group (X_{exp} =18,3; X_{con} =14,9). Table 5 presents the results of independent samples t-test for post tests of both groups.

Table 5. The Results of Independent Samples T-Test for Post Tests

Group	N	Mean	Ss	Sd	t	p
Experimental	25	47,2	15,5	48	2 222	0,002
Control	25	33,9	13,4	40	3,232	0,002

As seen in Table 5, significant difference is found between post test scores of the experimental and control groups as a result of independent samples t-test analysis ($t_{(48)}$ =3,232: p<0.05) in favor of the experimental group. The mean score of the experimental group's post test is quite higher than the control group's score (X_{exp} =47,2; X_{con} =33,9). Table 6 presents the results of independent samples t-test for delayed tests of both groups.

Table 6. The Results of Independent Samples T-Test for Delayed Tests

	Group	N	Mean	Ss	Sd	t	p
	Experimental	25	39,6	18,1	10	2 500	0.012
Ī	Control	25	28,5	11,3	48	2,399	0,012

There is a decrease in the scores of delayed test according to post test scores even though the experimental group's score is still higher than the control group (X_{exp} =39,6; X_{con} =28,5). Additionally, there is significant difference between delayed tests of the experimental and control groups ($t_{(48)}$ =2,599: p<0.05) in favor of the experimental group.

Table 7 presents the frequencies of PSTs' answers of pre, post and delayed tests according to categories for two-tier together.



Table 7. The Frequencies of PSTs' Answers of IMCCT According to the Categories

Categories	Ex	perimental Gr	oup	Control Group			
Categories	f_{pre}	$f_{ m post}$	$f_{ m delayed}$	f_{pre}	$f_{ m post}$	$f_{ m delayed}$	
RO-SU	18	125	89	9	80	47	
RO- PU	42	138	125	22 72		85	
FMO- SU	0	3	0	0	0	0	
E- SU	1	0	0	0	0	0	
RO -PUSAC	4	15	9	4	26	5	
FMO - PU	7	10	15	1 0	17 0	5	
E- PU	0	2	1			1	
RO -SAC	41	47	26	32	38	32	
RO -IEU	192	139	171	223	170	213	
FMO - PUSAC	2	14	11	6	17	2	
E- PUSAC	0	3	0	0	1	0	
FMO - SAC	126	115	91	72	108	84	
FMO - IEU	271	142	198	343	237	254	
E- SAC	0	0	1	1	1	3	
E- IEU	146	97	113	137	83	119	

According to Table 7, the frequencies of RO-SU and RO-PU categories in the experimental and control groups are considerably increased in post test. When delayed test scores are considered for the same categories, it is seen that the frequencies generally decreased according to post test scores. However, only the frequency of RO-PU category is slightly increased in the control group. Furthermore, an interesting point seen in the results of IMCCT is that although PSTs selected right option (RO) in the first tier of the questions, majority of them did not prefer to explain (IEU) in the second tier of the questions. This case was more seen in the control group than the experimental group. Moreover, it is seen that the frequencies of categories of post test were less than the other tests.

Another considerable point seen in Table 7 is that the frequencies of FMO-SAC, FMO-IEU, E-SAC and E-IEU categories which are very high. In post test, although the frequencies of these categories are significantly declined, the repeating of some expressions of PSTs that are classified in these categories is remarkable.

According to the groups, some alternative conceptions and their frequencies that were found in pre, post and delayed tests are presented in Table 8. These alternative conceptions were determined in the second tier of the questions in IMCCT.



Table 8. Alternative Conceptions and Their Frequencies Found In PSTs After IMCCT

Alternative Conceptions $ \begin{array}{c ccccccccccccccccccccccccccccccccccc$	Table 8. Alternative Conceptions and Their Frequencies Found In PSTs After IMCCT									
AC1. Impulse is impulsive force that substances applied to each other. AC2. Impulse means force exerted on an object, and then the change in acceleration or velocity is seen in the object. AC3. Momentum is a scalar quantity (not understanding that momentum is a vectorel quantity). AC4. Momentum is a pushing force. AC5. Momentum is a pushing force. AC6. Momentum is the multiplication of force and distance (confusing momentum with moment). AC7. The greater the mass, the greater the momentum. AC7. The greater the mass, the greater the momentum. AC8. Momentum is a concept based on solely and entirely velocity regardless of the mass. AC9. Momentum is preserved all time. AC10. Conservation of kinetic energy is required for momentum. AC11. Impulse is the vectorel summation of the first and last momentum. AC12. Momentum is preserved if impulse is exerted on the object. AC13. The direction of impulse is the same with the direction of momentum. AC14. Impulse is a force that is exerted on a unit time. AC15. Momentum is the ratio of force to mass. AC16. If gravity does not exist, then change in velocity is not seen. AC17. None of the components stay motionless that formed as a result of an internal explosion.	Alternative Concentions	Expe		l Group						
AC1. Impulse is impulsive force that substances applied to each other. AC2. Impulse means force exerted on an object, and then the change in acceleration or velocity is seen in the object. AC3. Momentum is a scalar quantity (not understanding that momentum is a vectorel quantity). AC4. Momentum is equal to impulse. AC5. Momentum is a pushing force. AC6. Momentum is the multiplication of force and distance (confusing momentum with moment). AC7. The greater the mass, the greater the momentum. AC8. Momentum is a concept based on solely and entirely velocity regardless of the mass. AC9. Momentum is preserved all time. AC10. Conservation of kinetic energy is required for momentum. AC11. Impulse is the vectorel summation of the first and last momentum. AC12. Momentum is preserved if impulse is exerted on the object. AC13. The direction of impulse is the same with the direction of momentum. AC14. Impulse is a force that is exerted on a unit time. AC15. Momentum is the ratio of force to mass. AC16. If gravity does not exist, then change in velocity is not seen. AC18. In inelastic collisions, coming object stops after hitting the motionless object.	_	$f_{\rm pre}$	$f_{\rm post}$	$f_{ m delayed}$	$f_{\rm pre}$	$f_{\rm post}$	$f_{ m delayed}$			
change in acceleration or velocity is seen in the object. AC3. Momentum is a scalar quantity (not understanding that momentum is a vectorel quantity). AC4. Momentum is equal to impulse. AC5. Momentum is a pushing force. AC6. Momentum is the multiplication of force and distance (confusing momentum with moment). AC7. The greater the mass, the greater the momentum. AC8. Momentum is a concept based on solely and entirely velocity regardless of the mass. AC9. Momentum is preserved all time. AC10. Conservation of kinetic energy is required for momentum. AC11. Impulse is the vectorel summation of the first and last momentum. AC12. Momentum is preserved if impulse is exerted on the object. AC13. The direction of impulse is the same with the direction of momentum. AC14. Impulse is a force that is exerted on a unit time. AC15. Momentum is the ratio of force to mass. AC16. If gravity does not exist, then change in velocity is not seen. AC18. In inelastic collisions, coming object stops after hitting the motionless object.	each other.			3		2	4			
momentum is a vectorel quantity). AC4. Momentum is equal to impulse. AC5. Momentum is a pushing force. AC6. Momentum is the multiplication of force and distance (confusing momentum with moment). AC7. The greater the mass, the greater the momentum. AC8. Momentum is a concept based on solely and entirely velocity regardless of the mass. AC9. Momentum is preserved all time. AC10. Conservation of kinetic energy is required for momentum's conservation. AC11. Impulse is the vectorel summation of the first and last momentum. AC12. Momentum is preserved if impulse is exerted on the object. AC13. The direction of impulse is the same with the direction of momentum. AC14. Impulse is a force that is exerted on a unit time. AC15. Momentum is the ratio of force to mass. AC16. If gravity does not exist, then change in velocity is not seen. AC18. In inelastic collisions, coming object stops after hitting the motionless object.		6	1	7	8	4	4			
AC4. Momentum is equal to impulse. AC5. Momentum is a pushing force. AC6. Momentum is the multiplication of force and distance (confusing momentum with moment). AC7. The greater the mass, the greater the momentum. AC8. Momentum is a concept based on solely and entirely velocity regardless of the mass. AC9. Momentum is preserved all time. AC10. Conservation of kinetic energy is required for momentum. AC11. Impulse is the vectorel summation of the first and last momentum. AC12. Momentum is preserved if impulse is exerted on the object. AC13. The direction of impulse is the same with the direction of momentum. AC14. Impulse is a force that is exerted on a unit time. AC15. Momentum is the ratio of force to mass. AC16. If gravity does not exist, then change in velocity is not seen. AC18. In inelastic collisions, coming object stops after hitting the motionless object.		10	7	11	4	7	6			
AC6. Momentum isthe multiplication of force and distance (confusing momentum with moment). AC7. The greater the mass, the greater the momentum. AC8. Momentum is a concept based on solely and entirely velocity regardless of the mass. AC9. Momentum is preserved all time. AC10. Conservation of kinetic energy is required for momentum's conservation. AC11. Impulse is the vectorel summation of the first and last momentum. AC12. Momentum is preserved if impulse is exerted on the object. AC13. The direction of impulse is the same with the direction of momentum. AC14. Impulse is a force that is exerted on a unit time. AC15. Momentum is the ratio of force to mass. AC16. If gravity does not exist, then change in velocity is not seen. AC17. None of the components stay motionless that formed as a result of an internal explosion. AC18. In inelastic collisions, coming object stops after hitting the motionless object.		-	9	8	-	4	2			
(confusing momentum with moment).7AC7. The greater the mass, the greater the momentum.181715101018AC8. Momentum is a concept based on solely and entirely velocity regardless of the mass.201010143124AC9. Momentum is preserved all time116175AC10. Conservation of kinetic energy is required for momentum's conservation.233-2-AC11. Impulse is the vectorel summation of the first and last momentum.164387AC12. Momentum is preserved if impulse is exerted on the object3-11AC13. The direction of impulse is the same with the direction of momentum.3134291AC14. Impulse is a force that is exerted on a unit time.13AC15. Momentum is the ratio of force to mass.3AC16. If gravity does not exist, then change in velocity is not seen.421252AC17. None of the components stay motionless that formed as a result of an internal explosion.10159119AC18. In inelastic collisions, coming object stops after hitting the motionless object.6119453	AC5. Momentum is a pushing force.	8	1	2	1	-	-			
AC7. The greater the mass, the greater the momentum. AC8. Momentum is a concept based on solely and entirely velocity regardless of the mass. AC9. Momentum is preserved all time. AC10. Conservation of kinetic energy is required for momentum's conservation. AC11. Impulse is the vectorel summation of the first and last momentum. AC12. Momentum is preserved if impulse is exerted on the object. AC13. The direction of impulse is the same with the direction of momentum. AC14. Impulse is a force that is exerted on a unit time. AC15. Momentum is the ratio of force to mass. AC16. If gravity does not exist, then change in velocity is not seen. AC17. None of the components stay motionless that formed as a result of an internal explosion. AC18. In inelastic collisions, coming object stops after hitting the motionless object.		7	-	-	3	-	-			
AC8. Momentum is a concept based on solely and entirely velocity regardless of the mass. AC9. Momentum is preserved all time. AC10. Conservation of kinetic energy is required for momentum's conservation. AC11. Impulse is the vectorel summation of the first and last momentum. AC11. Impulse is the vectorel summation of the first and last momentum. AC12. Momentum is preserved if impulse is exerted on the object. AC13. The direction of impulse is the same with the direction of momentum. AC14. Impulse is a force that is exerted on a unit time. AC15. Momentum is the ratio of force to mass. AC16. If gravity does not exist, then change in velocity is not seen. AC17. None of the components stay motionless that formed as a result of an internal explosion. AC18. In inelastic collisions, coming object stops after hitting the motionless object.		18	17	15	10	10	18			
AC19. Momentum is preserved all time. AC10. Conservation of kinetic energy is required for momentum's conservation. AC11. Impulse is the vectorel summation of the first and last momentum. AC12. Momentum is preserved if impulse is exerted on the object. AC13. The direction of impulse is the same with the direction of momentum. AC14. Impulse is a force that is exerted on a unit time. AC15. Momentum is the ratio of force to mass. AC16. If gravity does not exist, then change in velocity is not seen. AC17. None of the components stay motionless that formed as a result of an internal explosion. AC18. In inelastic collisions, coming object stops after hitting the motionless object.	AC8. Momentum is a concept based on solely and entirely	20	10	10	14	31	24			
AC10. Conservation of kinetic energy is required for momentum's conservation. AC11. Impulse is the vectorel summation of the first and last momentum. AC12. Momentum is preserved if impulse is exerted on the object. AC13. The direction of impulse is the same with the direction of momentum. AC14. Impulse is a force that is exerted on a unit time. AC15. Momentum is the ratio of force to mass. AC16. If gravity does not exist, then change in velocity is not seen. AC17. None of the components stay motionless that formed as a result of an internal explosion. AC18. In inelastic collisions, coming object stops after hitting the motionless object.		-	11	6	1	7	5			
AC11. Impulse is the vectorel summation of the first and last momentum. AC12. Momentum is preserved if impulse is exerted on the object. AC13. The direction of impulse is the same with the direction of momentum. AC14. Impulse is a force that is exerted on a unit time. AC15. Momentum is the ratio of force to mass. AC16. If gravity does not exist, then change in velocity is not seen. AC17. None of the components stay motionless that formed as a result of an internal explosion. AC18. In inelastic collisions, coming object stops after hitting the motionless object.	AC10. Conservation of kinetic energy is required for	2	3	3	-	2	-			
object. AC13. The direction of impulse is the same with the direction of momentum. AC14. Impulse is a force that is exerted on a unit time. AC15. Momentum is the ratio of force to mass. AC16. If gravity does not exist, then change in velocity is not seen. AC17. None of the components stay motionless that formed as a result of an internal explosion. AC18. In inelastic collisions, coming object stops after hitting the motionless object.	AC11. Impulse is the vectorel summation of the first and last	1	6	4	3	8	7			
of momentum. AC14. Impulse is a force that is exerted on a unit time. AC15. Momentum is the ratio of force to mass. AC16. If gravity does not exist, then change in velocity is not seen. AC17. None of the components stay motionless that formed as a result of an internal explosion. AC18. In inelastic collisions, coming object stops after hitting the motionless object. 3 13 4 2 9 1		-	-	3	-	1	1			
AC15. Momentum is the ratio of force to mass. AC16. If gravity does not exist, then change in velocity is not seen. AC17. None of the components stay motionless that formed as a result of an internal explosion. AC18. In inelastic collisions, coming object stops after hitting the motionless object. 3	1	3	13	4	2	9	1			
AC16. If gravity does not exist, then change in velocity is not seen. AC17. None of the components stay motionless that formed as a result of an internal explosion. AC18. In inelastic collisions, coming object stops after hitting the motionless object. AC18. In inelastic collisions, coming object stops after hitting the motionless object. AC18. In inelastic collisions, coming object stops after hitting the motionless object.	AC14. Impulse is a force that is exerted on a unit time.	1	-	-	3	-	-			
seen. 4 2 1 2 3 2 AC17. None of the components stay motionless that formed as a result of an internal explosion. 10 1 5 9 11 9 AC18. In inelastic collisions, coming object stops after hitting the motionless object. 6 11 9 4 5 3	AC15. Momentum is the ratio of force to mass.	3	-	-	-	-	-			
a result of an internal explosion. AC18. In inelastic collisions, coming object stops after hitting the motionless object. 10 1 3 9 11 9 4 5 3		4	2	1	2	5	2			
AC18. In inelastic collisions, coming object stops after hitting the motionless object. 6 11 9 4 5 3		10	1	5	9	11	9			
	AC18. In inelastic collisions, coming object stops after hitting	6	11	9	4	5	3			
1101), totally is transferred to anomies object in combitation. T 12 / J J J	AC19. Velocity is transferred to another object in collisions.	4	12	7	3	5	5			
AC20. Momentum is transferred to another object in collisions. 4 4 1 - 3 3		4								
AC21. Total velocity is conserved in collisions.		2	1	1	1	3	-			

As it can be seen in Table 8, data revealed that the participating students have some relatively more intense alternative conceptions such as AC3, AC4, AC7, AC8, AC9, AC13, AC17, AC18, and AC19, which might be explained as the teaching materials and teaching itself had limitations and even some hinderances that might led some participating students to develop alternative conceptions (AC4, AC13, AC18, AC19). For example E2, E13, E14, E16, C1, C2, C9 and C16 stated that in the interview "momentum was not changed because the velocity was not changed" and thus even after the intervention they did not understand that momentum was a vectorial quantity (AC3). Another interesting result showed that some of PSTs thought that velocity can be transferred as seen in AC19. However, E13, E14, C14 and C16 said in the interview that "motion is existed because velocity is transferred to another object in elastic collisions". If AC7 is considered in Table 8, it is seen that the intervention did not make a significant change in PSTs' minds because in the interview E1, E13, E14 and C1 stressed that "mass was important because the greater the mass, the greater the momentum" in a question that asking for the momentum of two objects with different masses were exerted by two equal forces during same time interval. In a similar vein, in the interview C1 made almost the same explanations for a different question seeking an answer for the momentum of two people having different masses that pushed each other and AC7 was not eliminated. It is seen that AC18 and AC19's frequencies increased after the intervention. Thus, in the interview E14 explained the differences between elastic and inelastic collisions such that "the objects stopped in inelastic collision" (AC18). E2, E13, E14 and C16 made an explanation in a case that two discs with equal masses which one of discs was motionless and one was active collided, then "one of the object transferred its velocity to the other object" (AC19).

On the other hand, the frequency of some alternative conceptions of PSTs was decreased (AC1, AC2, AC5, AC8, AC16, AC17, AC21) or even not seen (AC6, AC14, AC15) after the instructions. For example in the interview E1 made an explanation that "Impulse was not applied because the object was going with constant



velocity" and also C3, C6, C9 and C16 stated that "The person who was weaker had a bigger momentum because the object which had bigger velocity had bigger momentum" in the interview and it showed us that after the intervention AC2 and AC8 kept existing on PSTs' minds. In addition, C3, C6 and C16 said that in the interview question that asking for the momentum of two objects with different masses were exerted by two equal forces during same time interval "the smaller the mass, the greater the velocity; so the smaller the mass, the greater the momentum" and in a different question of the interview, C16 stressed that "the truck and the taxi collided head to head drag to the direction of the one having the greater velocity".

4. Discussion and Conclusions

This study revealed that explanation assisted REACT strategy which was based on context-based approach was found more effective than the traditional teaching approach on impulse, momentum and collisions topic. And according to this finding, it is evident that in physis teaching explanation assisted REACT strategy has positively affected PSTs' learning. Course materials prepared for the experimental group, contexts and citations for the contexts that were made in each stage of the intervention have been effective in keeping the interest of PSTs alive.

Also despite the fact that there is a decrease in delayed test mean scores from the post test, the t-test results show that there is a statistically significant difference in favor of the experimental group. This result suggests that the learning environment in which explanation assisted REACT strategy used is also more effective for permanent learning and retention of alternative concepts. The reason of this can be that daily life materials and contexts could have been effective because they may have attracted PSTs' attention and have made them to be more interested during the learning experience which was explanation assisted REACT strategy used (Rayner 2005). For instance, in advertising which was shown in collisions topic's relating principle, the different ways of collisions of vehicles were watched to attract the PSTs' attention. This material may have been effective in attracting PSTs' attention to the course because it included daily life conditions that they may have possibly encountered (Ültay & Çalık 2016).

"Ice rink" context used in the experimental group had been introduced at the beginning of the impulse and momentum topic by a reading text including some daily life examples PSTs could have lived. Because PSTs were accustomed to traditional teaching (i.e. teachers made presentations and PSTs took notes), to teach the topic in a different way could have made a positive impact on PSTs. This case is consistent with the results of some studies in which REACT strategy found effective instudents' achievement (Demircioğlu, Vural & Demircioğlu 2012; N. Ültay 2012). Moreover, it is known that traditional teaching approach is not such an effective way to teach at eliminating alternative concepts and constructing the new concepts (CORD 1999a; Kobayashi & Okiharu 2009; Ültay 2015; Westbrook & Marek 1991).

Findings remarkably showed that some of the participating PSTs developed some conceptions which were not seen in pre-tests. To have new alternative conceptions reveals that alternative conceptions interact with each other and they are part of the thinking system. In addition, it shows that alternative conceptions do not originate from one point. For instance, the alternative conception of "Momentum is equal to impulse" may have caused the formation of "The direction of impulse is the same with the direction of momentum". The thought of PSTs' "impulse was equal to momentum not to the change in momentum" can be a result of difficulty in understanding the relation between the impulse and momentum (Bryce & MacMillan 2009; Pride, Vokos & McDermott 1998). In fact, the explanations of PSTs during interview supported this thought. Because there was no change in velocities, PSTs thought that momentums were equal. The alternative conception of "Momentum is preserved all time" was emerged in the experimental group's post and delayed tests, and it requires PSTs understand the related and complex concepts in order to comprehend that momentum can be not preserved if external force exists (Bryce & MacMillan 2009). To have this alternative conception of PSTs is an indication of the weak connection between these concepts. Also, the samples exemplifying momentum's conservation which were given in the majority of materials and experiments used in the experimental group may give rise to this alternative conception. On the other hand, the alternative conception of "Conservation of kinetic energy is required for momentum's conservation" that emerged in the control group's post test supported this thought. The reason of this thought of PSTs in the control group may have resulted from the idea that kinetic energy and momentum should have been conserved together (Ünlüsoy 2006).

"Momentum is preserved if impulse is exerted on the object" was firstly determined in this study and it was seen in the control group's post and delayed tests and in the experimental group's delayed tests. The reason of this alternative conception's formation may be that some of PSTs thought that impulse was equal to change in momentum and so momentum conservation was seenif impulse was exerted. The alternative conception of "Momentum is transferred to another object in collisions" was determined in the control group's post and delayed tests and according to Grimellini-Tomasini, Pecori-Balandi, Pacca and Villani (1993), PSTs evaluated collisions as a single event and they ignored the other factors affecting the process. In addition, it can be caused by the difficulty of transferring the energy and momentum conservation knowledge to different situations (Singh



& Rosengrant 2003).

It is seen that some alternative conceptions (i.e "The greater the mass, the greater the momentum") were not eliminated although they were stressed by the activities and experiments. It shows that it is quite difficult to change hard-core alternative conceptions. The main point in failing some alternative conceptions' elimination may be following a logical sequence rather than a psychological sequence. For example, to teach firstly momentum and then velocity may prevent the formation of "Momentum is a concept based on solely and entirely velocity regardless of the mass".

According to this study's findings, it can be suggested for teachers and researchers an experimental design that should include two experimental and one control group. If in the first experimental group explanation assisted REACT strategy is used and in the second experimental group REACT strategy is used, then the effect of explanation assisted REACT strategy on learning impulse, momentum and collisions should be seen more clearly.

Note

This study is a part of the first researcher's PhD thesis which is entitled "Investigating the effect of the activities based on explanation assisted REACT strategy in context-based learning approach on impulse, momentum and collisions".

References

- Akdeniz, A. R., & Akbulut, Ö. E. (2010). Evaluation of the physics teacher candidates' constructivist teaching activities. *Necatibey Faculty of Education Electronic Journal of Science and Mathematics Education*, 4(1), 50-63.
- Akpınar, M. (2012). The effect of the conceptual change texts on student achievement gain at physics education carried out with context based approach. Unpublished doctoral dissertation, Gazi University, Ankara.
- Ayvacı, H. Ş., Çekbaş, Y., Değirmenci, S., Erdemir, M., Kara, M., & Toprak, Ş. (2011a). General Physics (5th Edition). M. Orbay & F. Öner (Eds.), In momentum and conservation of momentum (p. 127-146). Ankara: Pegem Academy Publication.
- Ayvacı, H. Ş., Değirmenci, S., Gümüş, S., İngeç, Ş., Öner, F., Ünlü, P., & Yılmazlar, M. (2011b). General Physics I (3rd Edition). M. F. Taşar & M. Orbay (Eds.), In momentum and impulse (p. 246-266). Ankara: Pegem Academy Publication.
- Ayvacı, H. Ş., Ültay, E., & Mert, Y. (2013). Evaluation of contexts appeared in 9th grade physics textbook.

 Necatibey Faculty of Education Electronic Journal of Science and Mathematics Education, 7(1), 242-263
- Basir, M. A., Alinaghizadeh, M. R., & Mohammedpour, H. (2008). A suggestion for improving students' abilities to deal with daily real-life problems. *Physics Education*, 43(4), 407-411.
- Bryce, T. G. K., & MacMillan, K. (2009). Momentum and kinetic energy: Confusable concepts in secondary school physics. *Journal of Research in Science Teaching*, 46(7), 739-761.
- Bueche, F. J., & Jerde, D. A. (2003). Principles of physics (Translated from the 6th Edition). K. Çolakoğlu (Trans. Ed.), In linear momentum (p. 170-198). Ankara: Palme Publication.
- Choi, J. S., & Song, J. (1996). Students' preferences for different contexts for learning science. *Research in Science Education*, 26(3), 341-352.
- CORD, (1999a). Teaching mathematics contextually. Waco, Texas, USA: CORD Communications, Inc.
- CORD, (1999b). Teaching science contextually. Waco, Texas, USA: CORD Communications, Inc.
- Coştu, S. (2009). Teacher experiences from a learning environment based on contextual teaching and learning in mathematics teaching. Unpublished master dissertation, Karadeniz Technical University, Trabzon.
- Crawford, M. L. (2001). Teaching contextually: Research, rationale, and techniques for improving student motivation and achievement in mathematics and science. Waco, Texas: CCI Publishing.
- Creswell, J. W. (2013). *Research design: Qualitative, quantitative, and mixed methods approaches*. Los Angeles: Sage Publication.
- Çalık, M. (2006). Devising and implementing guide materials related to solution chemistry topic in grade 9 based on constructivist learning theory. Unpublished doctoral dissertation, Karadeniz Technical University, Trabzon.
- Çirkinoğlu, A. G. (2004). Secondary and university students' level of understanding and development of learning on the topic of momentum. Unpublished master dissertation, Balıkesir University, Balıkesir.
- Demircioğlu, H., Vural, S., & Demircioğlu, G. (2012). The effect of a teaching material developed based on "REACT" strategy on gifted students' achievement. *Ondokuz Mayis University Journal of Faculty of Education*, 31(2), 101-144.
- Drew, C. J., Hardman, M. L., & Hart, A. W. (1996). *Designing and conducting research: Inquiry in education and social science* (2nd Edition). Boston: Allyn and Bacon.



- Enghag, M., Gustafsson, P., & Jonsson, G. (2009). Talking physics during small-group work with context-rich problems analysed from an ownership perspective. *International Journal of Science and Mathematics Education*, 7, 455-472.
- Fang, N. (2012). Students' perceptions of dynamics concept pairs and correlation with their problem-solving performance. *Journal of Science Education and Technology*, 21, 571-580.
- Finkelstein, N. (2005). Learning physics in context: A study of student learning about electricity and magnetism. *International Journal of Science Education*, 27(10), 1187-1209.
- George, E. A., Broadstock, M. J., & Vásquez Abad, J. (2000). Learning energy, momentum, and conservation concepts with computer support in an undergraduate physics laboratory. 4th International Conference of the Learning Sciences (pp. 2-3). Mahwah, NJ: Erlbaum.
- Gilbert, J. K. (2006). On the nature of "context" in chemical education. *International Journal of Science Education*, 28(9), 957-976.
- Grimellini-Tomasini, N., Pecori-Balandi, B., Pacca, J. L. A., & Villani, A. (1993). Understanding conservation laws in mechanics: Students' conceptual change in learning about collisions. *Science Education*, 77(2), 169-189.
- Hair, J. F., Black, B., Babin, B., Anderson, R. E., & Tatham, R. L. (2006). *Multivariate data analysis* (6th Edition). New Jersey: Prentice-Hall International.
- Imel, S. (2000). Contextual learning in adult education. Practice Application Brief, 12.
- Kandil İngeç, Ş. (2008). Using concept maps as an assestment tool in physics education. *Hacettepe University Journal of Education*, *35*, 195-206.
- Kobayashi, A., & Okiharu, F. (2009). Active learning approaches by visualizing ICT devices with milliseconds resolution for deeper understanding in physics. International Conference on Physics Education, USA.
- Landis, J. R., & Koch, G. G. (1977). The measurement of observer agreement for categorical data. *Biometrics*, 33(1), 159-174.
- Lye, H., Fry, M., & Hart, C. (2001). What does it mean to teach physics 'in context'? A first case study. *Australian Science Teachers Journal*, 48(1), 16-22.
- Marek, E. A. (1986). They misunderstand, but they'll pass. The Science Teacher, 32-35.
- Miles, M. B., & Huberman, A. M. 1994. *Qualitative data analysis* (2nd Edition). California: Sage Publications, Inc.
- Ng, W., & Nguyen, V. T. (2006). Investigating the integration of everyday phenomena and practical work in physics teaching in Vietnamese high schools. *International Education Journal*, 7(1), 36-50.
- Özmen, H. (2002). Learning theory and technology assisted constructivist learning in science education. *The Turkish Online Journal of Educational Technology*, *3*(1), 100-111.
- Park, J., & Lee, L. (2004). Analysing cognitive or non-cognitive factors involved in the process of physics problem-solving in an everyday context. *International Journal of Science Education*, 26(13), 1577-1595.
- Peşman, H., & Özdemir, Ö. F. (2012). Approach—method interaction: The role of teaching method on the effect of context-based approach in physics instruction. *International Journal of Science Education*, 34(14), 2127-2145.
- Pilot, A., & Bulte, A. M. W. (2006). Why do you "need to know"? Context-based education. *International Journal of Science Education*, 28(9), 953-956.
- Pride, T. O., Vokos, S., & McDermott, L. C. (1998). The challenge of matching learning assessments to teaching goals: An example from the work-energy and impulse-momentum theorems. *American Journal of Physics*, 66(2), 147-157.
- Rayner, A. (2005). Reflections on context-based science teaching: A case study of physics for students of physiotherapy. Uni Serve Science Blended Learning Symposium Proceedings, 169-172.
- Rennie, L. J., & Parker, L. H. (1996). Placing physics problems in real-life context: Students' reactions and performance. *Australian Science Teachers Journal*, 42(1), 55-59.
- Rennie, L. J., & Parker, L. H. (1998). Equitable measurement of achievement in physics: High school students' responses to assessment tasks in different formats and contexts. *Journal of Women and Minorities in Science and Engineering*, 4, 113-127.
- Sanger, M. S., & Greenbowe, T. J. (1996). Science-Technology-Society (STS) and ChemCom courses versus chemistry courses: Is there a mismatch?. *Journal of Chemical Education*, 73(6), 532-536.
- Sariay, M., & Kavcar, N. (2009). Investigation of the effectiveness of cooperative learning method on the impulse and momentum unit. *Journal of Buca Faculty of Education*, 25, 9-24.
- Serway, R. A., & Beichner, R. J. (2002). Physics for scientists and engineers with modern physics (Translated from the 5th Edition). K. Çolakoğlu (Trans. Ed.), In linear momentum and collisions (p. 251-291). Ankara: Palme Publication.
- Singh, C., & Rosengrant, D. (2003). Multiple-choice test of energy and momentum concepts. American Journal



- of Physics, 71(6), 607-617.
- Souders, J. (1999). Contextually based learning: Fad or proven practice. American Youth Policy Forum, July 9, Capitol, Hill.
- Şekercioğlu (Çirkinoğlu), A. G., & Kocakülah, M. S. (2008). Grade 10 students' misconceptions about impulse and momentum. *Journal of Turkish Science Education*, *5*(2), 47-59.
- Taber, K. S. (2007). The continuing relevance of thinking logically. *Physics Education*, 42, 120-121.
- Tan, K. C. D., Taber, K. S., Goh, N. K., & Chia, L. S. (2005). The ionisation energy diagnostic instrument: A two-tier multiple-choice instrument to determine high school students' understanding of ionisation energy. *Chemistry Education Research and Practice*, 6(4), 180-197.
- Tanel, Z., & Tanel, R. (2010). Determining the misconceptions and learning difficulties of undergraduate level students on topics of energy and momentum. *Balkan Physics Letters*, 18, 108-117.
- Taşar, M. F., Ünlü, P., & Kandil İngeç, Ş. (2006). Teacher candidates' understanding of momentum and impulse. Paper presented at GIREP 2006 Groupe International de Recherche sur I'Enseignement de la Physique, Amsterdam, The Netherland.
- Testa, I., Lombardi, S., Monroy, G., & Sassi, E. (2011). An innovative context-based module to introduce students to the optical properties of materials. *Physics Education*, 46(2), 167-177.
- Treagust, D. F. (1988). The development and use of diagnostic instruments to evaluate students' misconceptions in science. *International Journal of Science Education*, 10, 159-169.
- Ültay, E., & Ültay, N. (2014). Context-based physics studies: A thematic review of the literature. *Hacettepe University Journal of Education*, 29(3), 197-219.
- Ültay, N. (2012). Designing, implementation and comparison of materials about acids and bases based on REACT strategy and 5E model. Unpublished doctoral dissertation, Karadeniz Technical University, Trabzon.
- Ültay, N. (2015). The effect of concept cartoons embedded within context-based chemistry: Chemical bonding. *Journal of Baltic Science Education*, 14(1), 96-108.
- Ültay, N., & Çalık, M. (2016). A comparison of different instructional designs of 'acids and bases' subject. Eurasia Journal of Mathematics, Science and Technology Education, 12(1), 57-86.
- Ültay, N., Durukan, Ü. G., & Ültay, E. (2014). Determination of student teachers' views about REACT strategy, International Conference on Education in Mathematics, Science and Technology (ICEMST2014, May), Necmettin Erbakan University, Konya.
- Ünlü, P., Kandil İngeç, Ş., & Taşar, M. F. (2006). Investigating teacher candidates' knowledge structures about momentum and impulse by the method of using concept maps. *Education and Science*, 31(139), 70-79.
- Ünlüsoy, M. (2006). The effect of cooperative approach in determining and correcting the conceptual misconceptions in impulse and momentum two of the subjects in the schedule of physics lesson at high schools. Unpublished master dissertation, Gazi University, Ankara.
- Westbrook, S. L., & Marek, E. A. (1991). A cross-age of student understanding of the concept of diffusion. *Journal of Research in Science Teaching*, 28(8), 649-660.
- Wilkinson, J. W. (1999). Teachers' perceptions of the contextual approach to teaching VCE physics. *Australian Science Teachers Journal*, 45(2).
- Yapıcı, M. (2007). Teachers' attitudes and reflections. *Journal of Science, Education and Thought*, 7(3). Retrieved from http://www.universite-toplum.org/pdf/pdf_UT_327.pdf on 16.09.2015.